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AETHALZONZDAE: FUNCTIONAL EQUIVALENTS OF EXTRAFLORAL NECTARIES IN BAUHZNZA *(CESALPINIONIDEA)***

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RESUMEN
Aethalionidae:* Equilaventes funcionales de los nectarios extraflorales en *Bauhinia (Cesalpinionidea)

Bauhinia forficata Link es un árbol muy común en la región subtropical de América del Sur, donde se usa como árbol de sombra en zonas urbanas. *Aethalion reticulatum* (L.) es una de las numerosas especies de insectos fitófagos asociadas con este árbol. El insecto forma colonias en rama pequeñas, generalmente asociadas con hojas nuevas, flores y semillas en crecimiento. En Río Claro, Sao, Brasil, estas colonias son visitadas por seis especies de hormigas, siendo *Camponotus rufipes* (Fabricius) la más común. Mediante experimentación, se demostró que las colonias de *A. reticulatum* dependen de las hormigas para sobrevivir y que los daños en hojas, flores y semillas en crecimiento fue significativamente menor cuando *A. reticulatum* estaba presente. Sin embargo, esta protección no es efectiva frente a brúquidos predadores de semillas. Las colonias de *A. reticulatum* pueden ser más beneficiosas que perjudiciales a la planta y pueden considerarse como equivalentes funcionales de los nectarios extraflorales.

Palabras clave: *Aethalion, Camponotus, Bauhinia,* alimentación herbívora, hormiga, protección.

ABSTRACT

Bauhinia forficata Link (Cesalpinionidea), is a common tree of the sub-tropical region of South America, and is heavily utilized as an urban shade tree. Among many of the phytophagous insects associated with this species is the polyphagous *Aethalion reticulatum* (L.). This sap sucking bug forms colonies on small branches or the base of flowers and developing seed pods. Colonies are tended by at least 6 species of ants in Rio Claro, SP, Brazil, with the most prevalent being *Camponotus rufipes* (Fabncius). Through manipulative experiments, it was established that colonies of *A. reticulatum* depend upon ant care for survivorship, and that leaves, flowers and seed pods suffered significantly less herbivory when associated with *A. reticulatim* colonies, although pre-dispersa1 bruchid seed predation was not affected. Colonies of *A. reticulatum* may be more beneficia1 than detrimental to the plant, and pattems are similar to benefits reported for extrafloral nectaries.

Key words: *Bauhinia, Aethalion,* herbivory, protection, ant, *Camponotus.*

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INTRODUCTION

Many plant-sucking bugs are often considered pests, especially if attendant ants may also interfere with other herbivores and have a net beneficial impact upon the plant (LAINE & NIEMELA, 1980; BEATTIE, 1985; BUCKLEY, 1987). In these types of circumstances, the honeydew produced by sap-sucking bugs may be equivalent, in ecological terms, to the well documented beneficial effects of extrafloral nectaries (BENTLEY, 1977). Ants visiting extrafloral nectaries may protect foliage (TILMAN, 1978) or ovules and seeds (INDUYE & TAYLOS, 1979), which may result in greater seed set and increased plant fitness (BARTON, 1986; COMPTON & ROBERTSON, 1988). However, some researchers believe that extrafloral nectaries evolved to minimize the effects of sap-sucking insects (BECERRA & VENABLE, 1985), as plant protection provided by extrafloral nectaries varies temporally (TILMAN, 1978) and geografically (BARTON, 1986). If plant sap lost to sap-sucking insects is physiologically less costly than plant tissue lost to other types of herbivores, then selection should favor plants that harbor these insects, if these are protected by ants which interfere with other herbivores. Indeed, BENSON (1985) suggests that some myrmecophytic plants may have evolved special structures to harbor sap-sucking insects to obtain ant protection from other herbivores, and some plant-sucking bugs have carried this to the extreme by transferring parental care to attendant ants, and lowering mortality losses of progeny to predators and parasites (BRISTOW, 1982).

I report here on a series of field manipulations of attendant ants of *Aethalion reticulatum* (L.) (Aethalionidae) aggregations on a tree, *Bauhinia forficata* Link (Cesalpinionidea), devoid of extrafloral nectaries. *A. reticulatum* is a polyphagous sap-sucking bug (Homoptera), closely related to the Membracidae, and has been considered a pest in many cropping situations (BROWN, 1976). Female *A. reticulatum* guard first instar nymphs against parasitoids (BROWN, 1976). Also many ant species, as well as meliponid bees and vespid wasps have been mentiones as attending colonies of *A. reticulatum* (BROWN, 1976), but their presence has not been examined with respect to bug survivorship or costs or benefits to the host plant. Other types of herbivory were evaluated to determine if the ant — *A. reticulatum* mutualism is harmful, beneficial, or neutral (FRITZ, 1983). Manipulative experiments were also performed to determine the effect of ant attendance upon the survivorship of *A. reticulatum* under field conditions.

MATERIALS AND METHODS

Studies were performed in the city of Rio Claro, state of Sao Paulo, Brazil. B. *forficata* is a commonly used urban shade tree, and all studies reported here come from street or park situations. The polyphagous A. *reticulatum* forms aggregations which consist of cohorts of one to a few females, and associated nymphs. Aggregations are found at the ends of small branches associated with flower and seed pod bases, and leaf flushes 150 aggregations at leaf, 80 aggregations at seed pod bases, and 45 aggregations at pendant flowe bases, each divided into 3 equal groups, were marked and followed over a 4-weed period, at which time herbivore damage was recorded. A fourth group, consisting of similar situations without A. *reticulatum* present was also previously marked and established, serving as the control. For the first experimental manipulation, A *reticulatum* was physically removed after a one-week period. The second experimental manipulation consisted of excluding attendant ants from the aggregation by sticky banding with Tanglefoot. The remaining group had both ants and A. *reticulatum* present. Herbivore damage was scored as a percentage, using classes of 20%, for the following classes: visual leaf damage; visual seed pod damage; visual flower damage; and the percentage of seeds with developing bruchid beetle larvae. Only mandibulate insect damage was recorded for leaf and flower damage, while lygaeid damage was recorded for developing seed pods. In all cases, data were standardized based upon the maximal damage recorded scaled to 100%. The square-root of these data was then arc-sine transformed for statistical comparison.

To examine the effect of attendant ants on survivorship of A. *reticulatum,* a subgroup of 22 aggregations of a minimum fo 30 nymphs each were marked and followed every two days. Both the presence of the aggregation and the number of nymphs present were recorded. Both nymphal and aggregation survivorhip were analyzed because nymphal survivorship would indicate the adaptive value of ant protection to A. *reticulatum,* while aggregation survivorship would indicate that critica1 resources were still available for protection by attendant ants.

RESULTS

At least 6 species of ants were noted tending the A. *reticulatum* aggregations. No meliponid bees or vespid wasps were regularly recorded at the aggregations. Of the 85 aggregations with ants followed, *Camponotus rufpes* (Fabr.) was found at 57%, *Zacryptocerus pusillus* (Klug) at 17%, *Camponotus hrasiliensis* Mayr at 14%, *Camponutus renggeri* Emery at 5%, *Conomyrma* sp. at 4%, and, *Solenopsis saevissima* (F. Smith) at 3%. All ant species were found at different aggregations, and were apparently temporally mutually exclusive. Because of this fact, only the dominant *C. rufipes* was used for A. *reticulatum* survivorship studies, and other ant species were not evaluated. *C. rufpes* was found at aggregations during both day and night, and their effect on aggreations should not be confunded with other trophobiontic groups. In these cases, media workers were seen receiving honeydew from adults and nymphs following attenuation of the bugs, while minor and major workers were seen licking honeydew from the leaf surface.

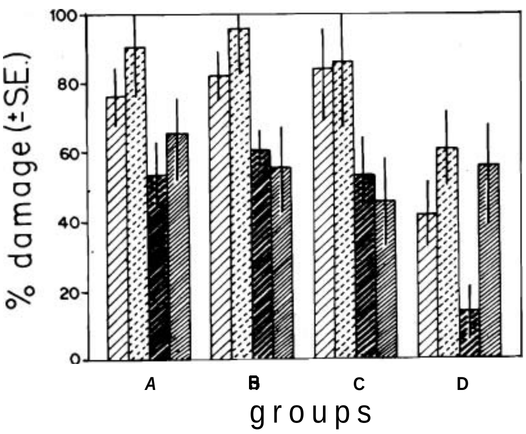

FIGURA 1. Means and standard errors of herbivore damage associated with experimental manipulations. Groups: A – control, naturally occumng situations devoid of *A. reticulatum* aggregations; *B – A. reticulatum* aggregations manually removed; C – ants excluded from *A. reticulatum* aggregations; *D – A. reticulatum* with attendant ants present. Bars: ist = leaf damage; 2nd = seed pod damage; 3rd = flower damage; 4th = bruchid damage to seeds.

Medias y desvíos estandardes de daños de herbivoria asociado con manipulaciones experimentales. Grupos. A – control, situaciones naturales sin agregaciones de *A. reticulatum* removidas manualmente; *C* – exclusión de hormigas de agregaciones de *A. reticulatum; D – A. reticulatum* con la presencia de hormigas. Barras: 1a = daño foliar; 2a = daño a vianas de semillas; 3a = daño a flores; 4a = daños a semillas por brúquidos.

Significantly less leaf flush, seed pod and flower damage was found ($P < 0.05$, ANOVA) for A. *reticulatum* aggregations with attendant ants (fig. 1). Among all other treatments, either control, with *A. reticulatum* removed, or with ants excluded from A. *reticulatum* aggregations, no significant differences were found. However, for the percentage of seed damage due to bruchid beetle larvae, no differences were found among the treatments (fig. 1).

A. reticulatum survivorship, both at the individual as well as at the aggregation level, were significantly increased with the presence of C. *rufpes* (fig. 2). Individual nymphal survivorship dropped quickly after ant exclusion, and at one week, the sizes of the aggregations were halved (fig. 2). However, the survival of the aggregation as an entity dropped at a much lower rate (fig. 2).

DISCUSSION

The results of these manipulative experiments under urban field conditions suggest that the impact of the ant-A. *reticulatum* mutualism is partly beneficia1 and partly neutral. In terms of leaf and flower mandibulate damage, and seed

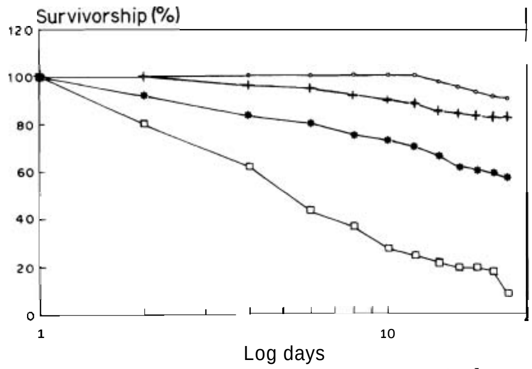

FIGURA 2. Survivorship curves for A. *reticulatum* nymphs (lowest) and aggregations (second lowest) after ant exclusion, compared with ant attendance on nymphs (second highest) and aggregations (highest).

Curvas de sobrevivencia para ninfas (más baja) e agregaciones (segunda más baja) de *A. rericulatum* después de exclusión de formigas, comparada con ninfas (segunda más alta) e agregaciones (más alta) en la presencia de hormigas.

pod sucking insect damage, apparently *A. reticulatum* does function as an ecological equivalent to extrafloral nectaries. However, losses of seeds to pre-dispersa1 bruchid seed predators is not lessened with attendant ants present. This may be due to the fact that *A . reticulatum* aggregations are only present at the developing seed pod bases, and not on the seed pods. Lygaeids, which attack seeds by sucking within the pods, may preferentially select seed pods for attack where ants are not in the immediate vicinity, while gravid bruchids apparently oviposit in seed pods from the pendant distal portion, and developing larvae which eat seeds are protected against ant attack within the seed pod.

These results, however, do not minimize the functional equivalency of *A. reticulatum* aggregations with extrafloral nectaries. In fact, if developing fruits are severely attacked, some plant species are known to only produce nectaries on these (ELÍAS, 1983). However, to properly evaluate the impact of *A. reticulatum* on the selective forcer of herbivory in B. *forficata*, short-term and long-term effects must be evaluated. For example, by reducing flower damage a larger seed set would be possible, especially if the physiological reserves, derived from photosynthesis in developing leaves, permitted. Thus if leaf damage was lower, more energy could be diverted into reproduction, and thus it may be misleading to evaluate percent bruchid seed damage without respect to the seed density, which was not evaluated here. Over the time period examined, however, the impact of *A. reticulatum* is well within the expected benefits of the possession os extrafloral nectaries (KoPTUR, 1991).

Although it was not possible to distinguish the relative contribution of female protection of nymphs with ant protection, the significantly lower survivorship curves found for both nymphal numbers and aggregation longeveity in the absence of ant attendance suggests that C. *rufipes* has a major role in the population dynamics of *A. reticulatum* in the study area. In the absence of ants, higher mortality rates for both aggregations and nymphs were recorded.

The interactions between aggregation numbers and sizes on leaf, flower and seed sucking damages were beneficia1 for plant fitness when protected by ants. Although bruchid beetle seed predation was not affected by the presence of C. *rufipes* at *A. reticulatum* aggregations, other herbivore damage was reduced which should contribute to an increased fitness of B. *forficulata* plants which harbor *A. reticulatum* colonies. Although this mutualism is conditional (CUSHMAN & ADDICOTT, 1991), the benefits are at worst neutral, if only bruchid seed predation is examined, and for other measured portions of B. *forficata* fitness are apparentely beneficial.

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